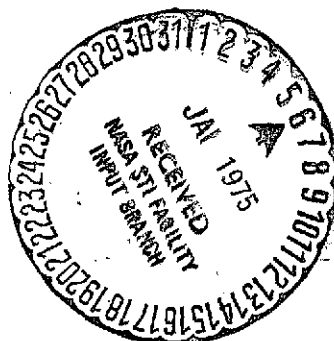


FLIGHT TESTS IN THE WIND TUNNEL FOR THE DEVELOPMENT AND
TESTING OF A GUST ALLEVIATION SYSTEM

Bernd Krag and Henning Subke

(NASA-TT-F-16079) FLIGHT TESTS IN THE WIND TUNNEL FOR THE DEVELOPMENT AND TESTING OF A GUST ALLEVIATION SYSTEM (Scientific Translation Service) 10 p HC \$3.25 CSCL 01B G3/02 04963 N75-12902 Unclas

Translation of: "Flugversuche im windkanal zur entwicklung und erprobung eines boenabminderungssystems," DFVLR Nachrichten, July 1974, pp. 561 - 562.



1. Report No. NASA TT F 16,079		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle FLIGHT TESTS IN THE WIND TUNNEL FOR THE DEVELOPMENT AND TESTING OF A GUST ALLEVIATION SYSTEM				5. Report Date 23 December 1974	
				6. Performing Organization Code	
7. Author(s) Bernd Krag and Henning Subke				8. Performing Organization Report No.	
				10. Work Unit No.	
9. Performing Organization Name and Address SCITRAN Box 5456 Santa Barbara, CA 93108				11. Contract or Grant No. NASw-2483	
				13. Type of Report and Period Covered Translation	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546				14. Sponsoring Agency Code	
15. Supplementary Notes Translation of: "Flugversuche im windkanal zur entwicklung und erprobung eines boenabminderungssystems," DFVLR Nachrichten, July 1974, _____ pp. 561 - 562. (A74-39407)					
16. Abstract The Institute for Flight Mechanics of the DFVLR, Braunschweig, West Germany, is developing a free flight, elastic CCV (Controlled Configured Vehicle) wind tunnel model with which aircraft responses and controller responses to gust simula- tions will be tested. The model represents a compromise between computer simulation and actual flight tests. The many advantages of this approach are enumerated.					
17. Key Words (Selected by Author(s))			18. Distribution Statement Unclassified - Unlimited		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 8	22. Price		

FLIGHT TESTS IN THE WIND TUNNEL FOR THE DEVELOPMENT AND TESTING OF A GUST ALLEVIATION SYSTEM

Bernd Krag and Henning Subke*

The testing of new and unconventional flight controllers /561** in aircraft is expensive and involves considerable safety risks. The disadvantages can be avoided if tests are carried out with a scale model which can carry out free flight in the wind tunnel. At the Institute for Flight Mechanics, we are testing a flight controller which will alleviate flight conditions in gusty air and, at the same time, will reduce the deformations of lifting surfaces and the fuselage. An elastic wind tunnel model is used for this which can move freely from its free flight suspension. The controls of aircraft motion and the intervention of the new type of flight controller is done by means of electrically driven aerodynamic surfaces on the wing and tail plane.

Increased performance requirements for aircraft have made it necessary to use flight controllers for various tasks, with increasing amounts of responsibility. The development leads to aircraft which can only be flown with controllers. Such aircraft (Control Configured Vehicles = CCV), in which the flight controller is already planned in the design of the stabilization and control tasks, will differ considerably from conventional aircraft, even in the external features (Figure 1).

*Institute for Flight Mechanics of the DFVLR, Braunschweig.

**Numbers in the margin indicate pagination of original foreign text.

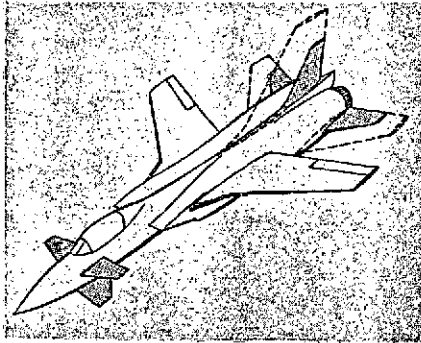


Figure 1. Possible configuration changes of an aircraft by CCV technology.

flight through a gust field. There, we wish to bring about the following:

1. an improvement in the aircraft as a working platform and increased travel comfort, as well as
2. an increase in the aircraft lifetime by reducing material fatigue.

There are three different possibilities of investigating this topic.

Computer simulation: The disadvantage of this method is that a computer simulation does not yet represent a sufficient condition for the technical design and realization of a theoretically optimized control system. Already in the mathematical description of the control loop (aircraft) and of the measurement and actuator system, there are a number of simplifying assumptions which have to be made.

Flight experiments: Experimental flights must be carried out at the end of a new development and involve the area of flight control and regulation. The testing of partially unstable and controller-supported CCV aircraft is connected with great risks, and the related technical expense for bringing about the high reliability is high. In addition, experimental aircraft can only be varied within limits, so that the transfer of information can only be done in a limited way to other aircraft.

Wind tunnel experiments: In the Institute Division for Flight Mechanics of Aircraft, we are pursuing a third course, which represents a compromise between computer simulation and flight testing. This is the simulation in a wind tunnel using "free flight" elastic and aerodynamic models which can be controlled (Figure 2). For example, the problem of producing an optimum gust aviation system can be solved more easily under realistic conditions. A model can be quickly changed so that the various aircraft configurations can be investigated and the selected controller can be tested. This method is relatively cost effective and provides general flight mechanical data on such flight controller systems over a wide range. Another 562 important reason is that experiments can be carried out without involving the safety risk for the crew and the aircraft.

The elastic wind tunnel model (Figure 3) was prepared by the Institute Division for Flight Experimentation Technology. It contains electrically driven elevator rudders as well as outboard wind flaps, which are operated by magnetic drives developed by our Institute. In addition, the elevator rudder trim angle can be electrically adjusted. The inboard wind flaps will be installed shortly and they will have electrical drives. The measurement of the model motions is done in a uniform way using miniaturized accelerometers. The change in the incident

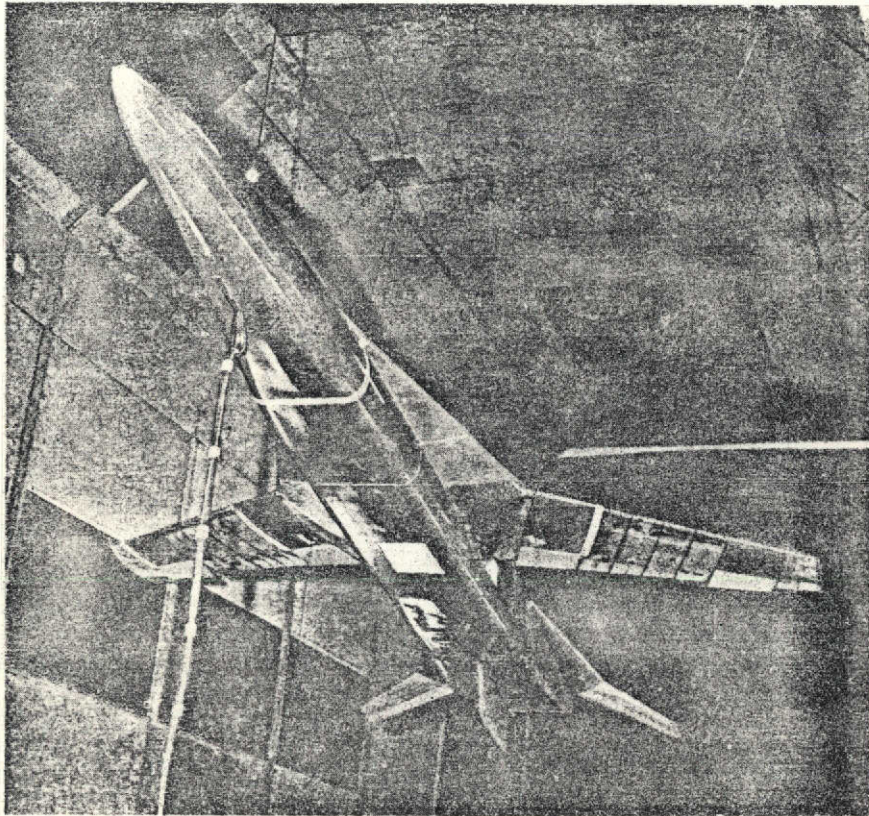


Figure 2. CCV flight model in the wind tunnel.

flow direction of the model when flying through a gust field is measured with special probes. A "sled" is installed in the vicinity of the center of gravity in the model, which guides the model along a guiding rod and allows lifting and pitching motions during the first test phase. The main problem in the design of a free flight suspension was to make the eigen frequency of the construction lie outside of the eigen frequency of the model and the gust field. In order to allow the model to fly at various angles of attack, there is an automatic weight compensation. This installation provides a fast adjustment of various flight states.

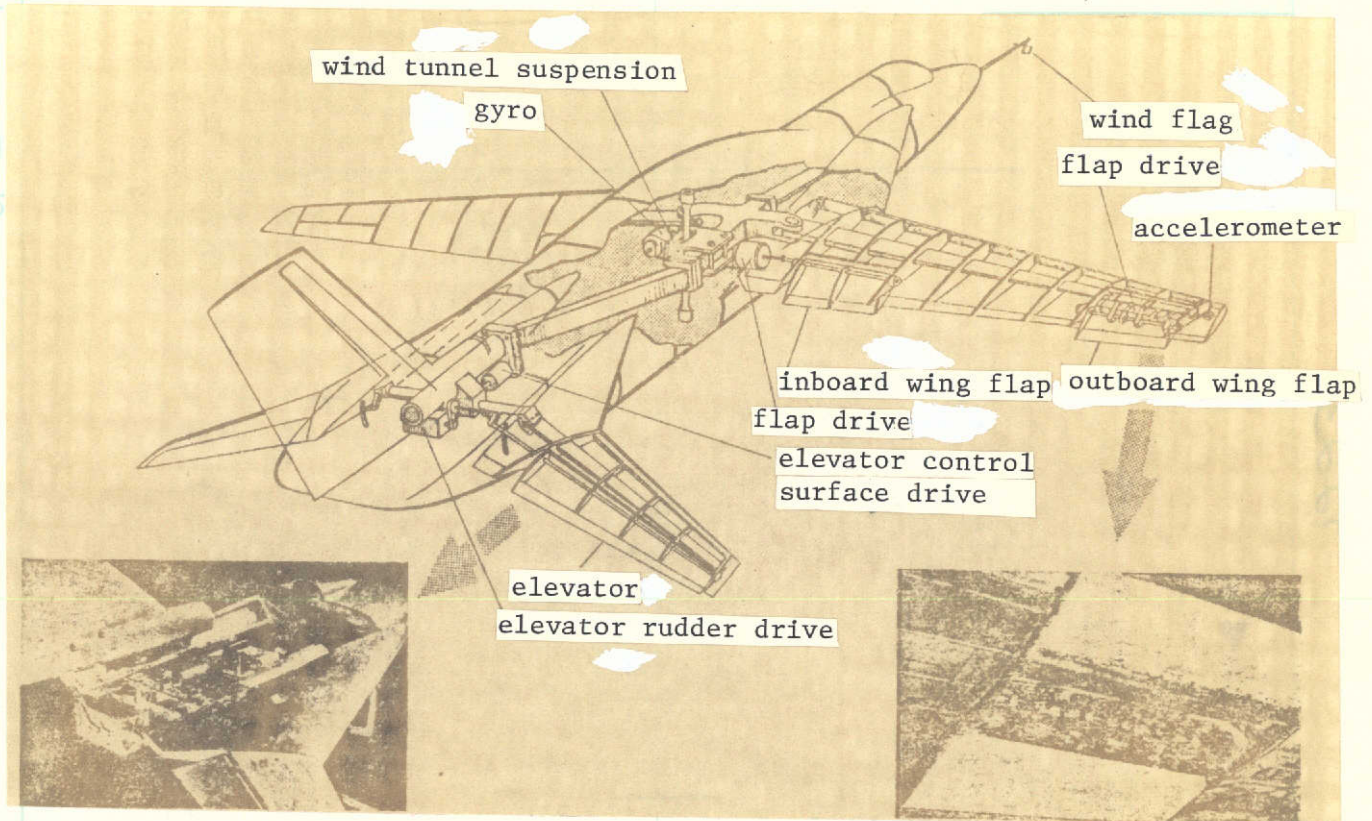


Figure 3. Integration of electrically controllable aerodynamic control surfaces in the flexible aircraft model EM 1 of the Flight Mechanics Institute.

In the central division for low velocity wind tunnels of the DFVLR Research Center at Braunschweig, we are carrying out preliminary experiments for producing gusts in the wind tunnel. In collaboration with the Aeroelasticity Institute of the DFVLR in Goettingen, we are carrying out test stand oscillation experiments in order to provide knowledge on the elastomechanical oscillation modes of the model. After this, we will perform the first wind tunnel experiments with the free flight suspension, and a first controller model will attempt to attenuate artificially induced elastic deformations of the model. In collaboration with the Mechanical Center of the Technical University of Braunschweig, at the present time we are carrying out computer

simulations with such a controller. We were able to demonstrate that this controller is basically suited for the test. In addition, there are close scientific contacts in the area of gust simulation with the ONERA in France and the area of model technology with the MBB Aircraft Division in Ottobrunn.

In the following year, we will make geometric (by modifying and adding control surfaces) and dynamic (by mass distribution) changes. In addition, the measuring system will be modified by other transducer types and positions. By varying the parameters, one finally obtains a complete spectrum of model configurations which are representative for a large number of aircraft and their optimized controllers. By considering the nonlinearities of the aerodynamic type (dead times) and mechanical type (rudder deflection limitation) in the optimum adaptation of the controller to the model, the method described here represents a valuable tool for solving flight mechanical problems of future aircraft.

Finally, we should note that the problem formulated for the research project* has a strong interdisciplinary character because of the interaction of the inertial and stiffness forces and the aerodynamic and controller forces, so that the close scientific contact in flight mechanics to other disciplines in aerodynamic research, such as for example control technology, aeroelasticity, and aerodynamics, will be found to be especially advantageous.

*P. Hamel. Present Problems of Flight Mechanics. DVFLR Nachrichten, No. 5, August, 1971, pp. 190 - 191.

Translated for National Aeronautics and Space Administration under Contract No. NASw-2483 by SCITRAN, P. O. Box 5456, Santa Barbara, California 93108.